Title: Parallel Lines

Brief Overview:

In this set of three lessons students will use Geometer's Sketchpad to explore relationships between parallel lines and transversals. Topics will include identifying angles formed by the lines and transversals, applying relationships to determine whether lines are parallel or non-parallel, and solving problems through application of the relationships. Discoveries made will be used to lead students through postulates and theorems related to parallel lines. Lesson three in the series places emphasis on application of the relationships, theorems and postulates discussed earlier to solve geometric problems. Construction exercises are included as extension activities in the lessons.

Prior to introducing this lesson, the students should be able to construct line segments, place points at intersections, measure angles, and label geometric figures using the text feature.

Teachers could either introduce these commands, or, use one of the many resources available. One resource is The Geometer's Sketchpad Workshop Guide by Key Curriculum Press 2002 (pages 2-3) available on the Internet. A ten minute introduction should suffice.

NCTM Content Standard/National Science Education Standard:

All students should analyze properties and determine attributes of two- and three-dimensional objects.

All students should explore relationships (including congruence and similarity) among classes of two- and three-dimensional geometric objects, make and test conjectures about them, and solve problems involving them.

All students should establish the validity of geometric conjectures using deduction, prove theorems, and critique arguments made by others.

All students should draw and construct representations of two- and three-dimensional geometric objects using a variety of tools.

Grade/Level:

High School Geometry

Duration/Length:

Approximately three 45 minute periods will be required to present these lessons.

Student Outcomes:

Students will:

- Be able to distinguish between intersecting lines, parallel lines and skew lines.
- Identify angles formed when two lines are cut by a transversal.
- Apply angle relationships between lines and transversals to determine whether or not lines are parallel.
- Identify, use and apply postulates and theorems related to parallel lines and transversals.

Materials and Resources.

- Class set of colored pencils or markers. Recommend four colors and enough sets for one per every two students.
- Access to Geometer's Sketchpad (either in a lab setting or for projection from a single computer in a classroom setting).
- Overhead projector and transparencies.

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Development/Procedures:

Lesson 1 – Exploring Angles of Parallel Lines

Preassessment/Launch. Have students define the following terms: point, line, plane, parallel lines, skew lines, coplanar. (This can be done verbally or in writing). Use discussion of this material to introduce the topic of the lesson.

Teacher Facilitation. Use Geometer's Sketchpad, an overhead projector or the blackboard to define transversal (a line that intersects two or more coplanar lines in different points) and parallel lines (two or more coplanar lines that do not intersect). Note that in the next three lessons we will be considering relationships among angles formed by parallel lines and transversals and we will be applying these relationships to solve problems. Use Geometer's Sketchpad to demonstrate how to construct parallel lines and a transversal. For this activity demonstrate using horizontal parallel lines, as in the figure below. Activities included in Parts Two through Six will involve changes in the transversal and the direction of the parallel lines. For reference purposes, steps to follow to complete the construction of parallel lines on Geometer's Sketchpad are listed on Handout 1.1. To complete the activity on Handout 1.1, students will need to know how to use Geometer's Sketchpad to construct parallel lines, construct a transversal, use the text feature to number angles and measure angles.

Remind students that to measure an angle, the vertex and a point on each side of the angle must be selected.
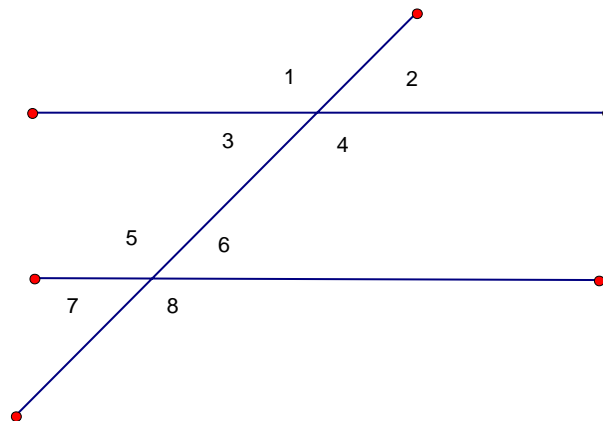
Student Application.
Part One.
After the demonstration is completed, refer students to Handout 1.1 and ask them to complete the tasks outlined in the handout.

Part Two.
Ask students to click on one end of the segment forming the transversal in their diagram and adjust the slant of the transversal by dragging the end point. Have students explore

relationships among the angles as they did in Activity One. Handout 1.1 can be used to guide their exploration and record results.

Embedded Assessment.
As students work on Parts One and Two, the teacher should circulate among the students. This will provide an opportunity to assist students, to assess student's skills related to use of Geometer's Sketchpad and to observe results of their explorations. Build on findings from this embedded process by seeking student input to questions presented in Part Three.

Part Three.
Sketch two parallel lines and a transversal. Using this sketch as a visual aid, call on student volunteers to share results of their explorations. Steer the discussion with students to ensure that the angle pairs listed below are identified and understood. As a part of this guided discussion, the Teacher could mark pairs of the above angles by using the Construct and Interior features in Geometer's Sketchpad. For example corresponding angles could be colored yellow, same-side interior angles red and so forth.

> Alternate Interior Angles
> Same-Side Interior Angles (also called consecutive interior angles)
> Corresponding Angles.

Part Four. (OPTIONAL)
If additional practice is necessary to ensure that students grasp the angle pair relationships, sketch parallel lines and a transversal on the overhead, blackboard or Geometer's Sketchpad and call on students to name pairs of angles and their relationship (eg supplementary, congruent) as they are identified on the visual aid. This activity could be extended by having students work in pairs to construct parallel lines and transversals and practice naming angle pairs.

Part Five.
Theorems and Postulates. State and explain the theorems and postulates listed below to the class, ensuring that as each is described it is associated with the appropriate angle pair.
    - Postulate. If two parallel lines are cut by a transversal, then corresponding angles are congruent.

    - Theorem. If two parallel lines are cut by a transversal, then alternate interior angles are congruent.

    - Theorem. If two parallel lines are cut by a transversal, then same-side interior angles are supplementary.
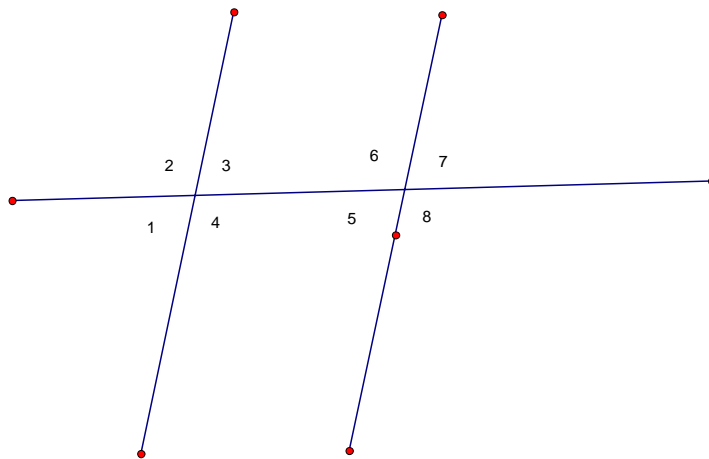
    - Theorem. If a transversal is perpendicular to one of two parallel lines, then it is perpendicular to the other one also.

Part Six. Real Life Application. As a capstone activity, lead a discussion of real life applications of parallel lines. Samples of topics that might be cited by students could include: railroad tracks, cars traveling in opposite direction on a two lane road, aircraft flying in "planes" at different altitudes to control traffic and avoid head on collisions, planting gardens in rows, siding on houses.
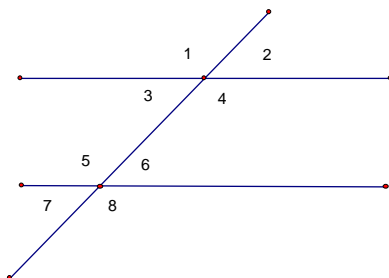
Reteaching/Extension (Optional).

Part Seven.
Use Part Seven if assessment indicates need for reteaching Have students use Geometer's Sketchpad to construct parallel lines and a transversal oriented as in the diagram below. Ask students to name the angle pairs and relationships.

Worksheet 1.1

NAME: _____ DATE _____

       Use Geometers's Sketchpad to construct two horizontal parallel lines and a transversal that approximate those drawn below. Steps to complete the construction are listed below the drawing.

1. Use the Straightedge Tool to construct a line segment.
2. Use the Point Tool to construct a point above the line segment.
3. Use the Selection Tool to select the line segment and the point just constructed.
4. Select the Construct icon, then select Parallel Line to construct a line through the point that is parallel to the first line segment.
5. Use the Straightedge Tool to construct a transversal that intersects the two parallel lines. Don't forget to locate and identify the two intersection points.
6. Use the Text tool to number the angles (hint: double click on the text tool icon to open a text box in which you can type the angle numbers).
7. Recall that three points are needed to measure an angle.

   Once the construction is complete, use the Measure tool (set preferences to round angle measurements to the unit) in Geometer's Sketchpad to explore relationships among angles 1 through 8. To complete this activity, make conjectures (an unproven statement based on observations) about the relationships between the pairs of angles in the table below and then test the conjectures with the aid of the Measuring tool in Geometer's Sketchpad. Briefly summarize your findings in the table. Select additional pairs to extend your research.
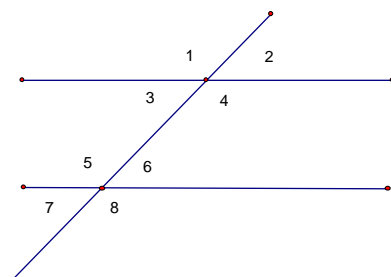
	Part One		Part Two	
Angle Pair	**Conjecture**	**Findings**	**Conjecture**	**Findings**
<1 and <4	Congruent/ Vertical angles	Both angles measure 134 °		
<6 and <7				
<3 and <6				
<4 and <5				
<4 and <6				
<5 and <3				
<2 and <6				
<3 and <7				

Worksheet 1.1

NAME_____DATE_____

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4. Select the Construct icon, then select Parallel Line to construct a line through the point that is parallel to the first line segment.
5. Use the Straightedge Tool to construct a transversal that intersects the two parallel lines. Don't forget to locate and identify the two intersection points.
6. Use the Text tool to number the angles (hint: double click on the text tool icon to open a text box in which you can type the angle numbers).
7. Recall that three points are needed to measure an angle.

　　　　Once the construction is complete, use the Measure tool (set preferences to round angle measurements to the unit) in Geometer's Sketchpad to explore relationships among angles 1 through 8. To complete this activity, make conjectures (an unproven statement based on observations) about the relationships between the pairs of angles in the table below and then test the conjectures with the aid of the Measuring tool in Geometer's Sketchpad. Briefly summarize your findings in the table. Select additional pairs to extend your research.

| | **Part One** | | **Part Two** | |
Angle Pair	**Conjecture**	**Findings**	**Conjecture**	**Findings**
<1 and <4	Congruent/ vertical angles	Both angles measure 134°	Note: answers depending on Constructions.	will vary individual
<6 and <7	≅/vertical angles	Both are 46 °		
<3 and <6	≅/alt Int. angles	Both are 46 °		
<4 and <5	≅/alt int. angles	Both are 134 °		
<4 and <6	Supp. angles	Add up to 180 °		
<5 and <3	Supp. Angles	Add up to 180 °		
<2 and <6	≅/corr. Angles	Both are 46 °		
<3 and <7	≅/corr. Angles	Both are 46 °		
Footnote to teacher: Specific angle names are not provided until Part 3 of Lesson 1.				

Lesson 2 - Emphasis on Non-parallel Lines

Preassessment/Launch – Give students a copy of the handout "Lesson 2 – Warm-up." Students will label the diagram with the terms associated with parallel lines and transversals: alternate interior angles, corresponding angles, and same-side interior angles. Students will then write the theorems that apply to parallel lines.

Example: If two parallel lines are cut by a transversal, then corresponding angles are congruent.

Prompt students to give examples from real life that represent parallel lines. Note: this is a continuation of Part 6 of Lesson 1 which discusses real-life applications. Responses could include two-lane highways, railroad tracks, etc. Ask students what would happen if these examples were no longer parallel. A train could derail, for example, if one of the tracks were tampered with and was not exactly parallel to the other track.

Teacher Facilitation/ Student Application – Have students use Geometer's Sketchpad to complete Worksheet 2.1. Students will use definitions and properties of parallel lines (equidistant, lines never meet, same slope) to show that their pair of lines is non-parallel. Students will then discuss their findings. Students will then complete Worksheet 2.2.

Students will observe that pairs of alternate-interior angles and corresponding angles are not congruent, and that same-side interior angles are not supplementary when lines are not parallel.

Reteaching/Extension – Students are introduced to a real-life application using parallel lines. Students will study a diagram of a periscope from a submarine. The mirrors in a periscope are parallel and reflect light at the same angle. Using Geometer's Sketchpad, students will construct a simplified model of a periscope and identify the parallel lines, the transversal, and alternate interior angles. They will then identify pairs of congruent angles.

Embedded Assessment 1 – The students will draw freehand a diagram showing the path of light coming into a periscope.

Embedded Assessment 2 – Ask the students in a class discussion what would happen if one of the mirrors slipped slightly out-of-place so that it no longer reflected light at the same angle as the other mirror? The students will draw a diagram showing the new path of light coming into the periscope. Where would the light be reflected then?
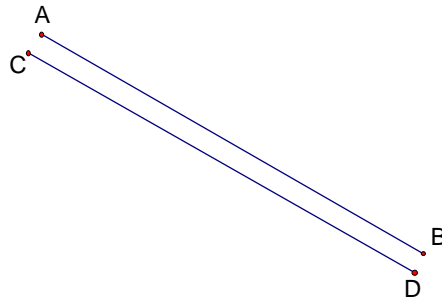
Worksheet 2.1

NAME_____DATE_____

Working with Lines that aren't Parallel

Using Geometer's Sketchpad you will explore properties of non-parallel lines.

1. Open a New Sketch and draw a segment AB like the one below. Draw another segment CD like the one below. How can you determine that the two segments are <u>not</u> parallel?
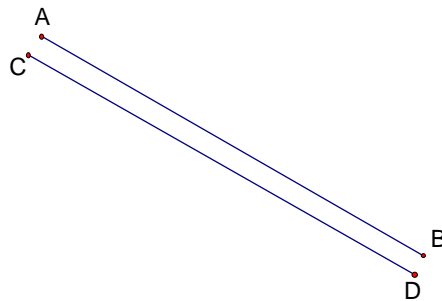
_____

_____

_____

Worksheet 2.2

NAME_____DATE_____

Working with Lines that aren't Parallel

1. Remember that parallel lines are equidistant from each other. You can check
    distances with Geometer's Sketchpad. Construct a point near one end of your
    segment. Select this point and Construct a Perpendicular Line to the other line
    segment. You need to construct the intersection point before measuring the
    distance (i.e., points F and E). Select the Measure , then DISTANCE command.
    Make sure your EDIT…PREFERENCES are set to at least the tenths place.

GH = 0.61 cm

EF = 0.63 cm
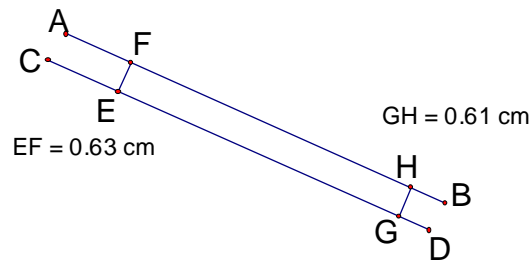
Write your measured distance near one end (tenths) _____

Write your measured distance closer to the other end (tenths) _____

Are your two lines parallel? _____

2.   Parallel lines also have the same slope, or steepness. In Algebra 1 you learned how to
    determine slope if you had two points on a line. Geometer Sketchpad will automatically
    calculate the slope of a line. Simply select your line, type MEASURE, then SLOPE.
    Select your two line segments. Determine and write their slopes below.

    Slope of AB = _____   Slope of CD = _____


3. Draw a transversal intersecting your two line segments. Use your angle relationships to
    determine whether or not your lines are parallel. Describe one of three angle
    relationships below. (From Lesson 1)

4. Verify your conclusion by measuring pairs of angles. Write those measurements below.
   Make sure that your angles are labeled.

_____   _____

_____   _____

_____   _____

Worksheet 2.1 – Teacher's Guide

NAME_____DATE_____

Working with Lines that aren't Parallel

Using Geometer's Sketchpad you will explore properties of non-parallel lines.

1. Open a New Sketch and draw a segment AB like the one below. Draw another segment CD like the one below. How can you determine whether or not the two segments are parallel?

At some point the two lines will intersect._____

The distance between the two points will vary._____

Their slopes will be different._____

Note: Any of these answers would be sufficient. Worksheet 2.2 explores these concepts in more detail. Students need to recall that the distance between a point and a line is the perpendicular from that point to that line.

Worksheet 2.2 – Teacher's Guide

NAME_____DATE_____

Working with Lines that aren't Parallel

1) Remember that parallel lines are equidistant from each other. You can check distances with Geometer's Sketchpad. Construct a point near one end of your segment. Select this point and Construct a Perpendicular Line to the other line segment. You need to construct the intersection point before measuring the distance (i.e., points F and E). Select the Measure , then DISTANCE command. Make sure your EDIT…PREFERENCES are set to at least the tenths place.
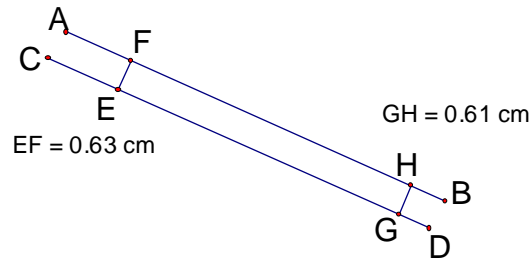
Write your measured distance near one end (tenths)___ _Answers will vary_

Write your measured distance closer to the other end (tenths)__ _Answers will vary_

Are your two lines parallel? _If the distances are different, then the lines are non-parallel._

2) Parallel lines also have the same slope, or steepness. In Algebra 1 you learned how to determine slope if you had two points on a line. Geometer Sketchpad will automatically calculate the slope of a line. Simply select your line, type MEASURE, then SLOPE. Select your two line segments. Determine and write their slopes below.

   Slope of AB = _Answers will vary._____   Slope of BC = _Answers will vary._____

3) Draw a transversal intersecting your two line segments. Could you use angle relationships to determine whether or not your lines are parallel? Describe one of three angle relationships below. (From Lesson 1)

Example: If two lines are cut by a transversal, the same-side interior angles are supplementary.

4) Verify your conclusion by measuring pairs of angles. Write those measurements below. Make sure that your angles are labeled.

 Angle measurements should not be congruent

_____   _____

_____   _____

_____   _____

Given: a || b

c

a

b
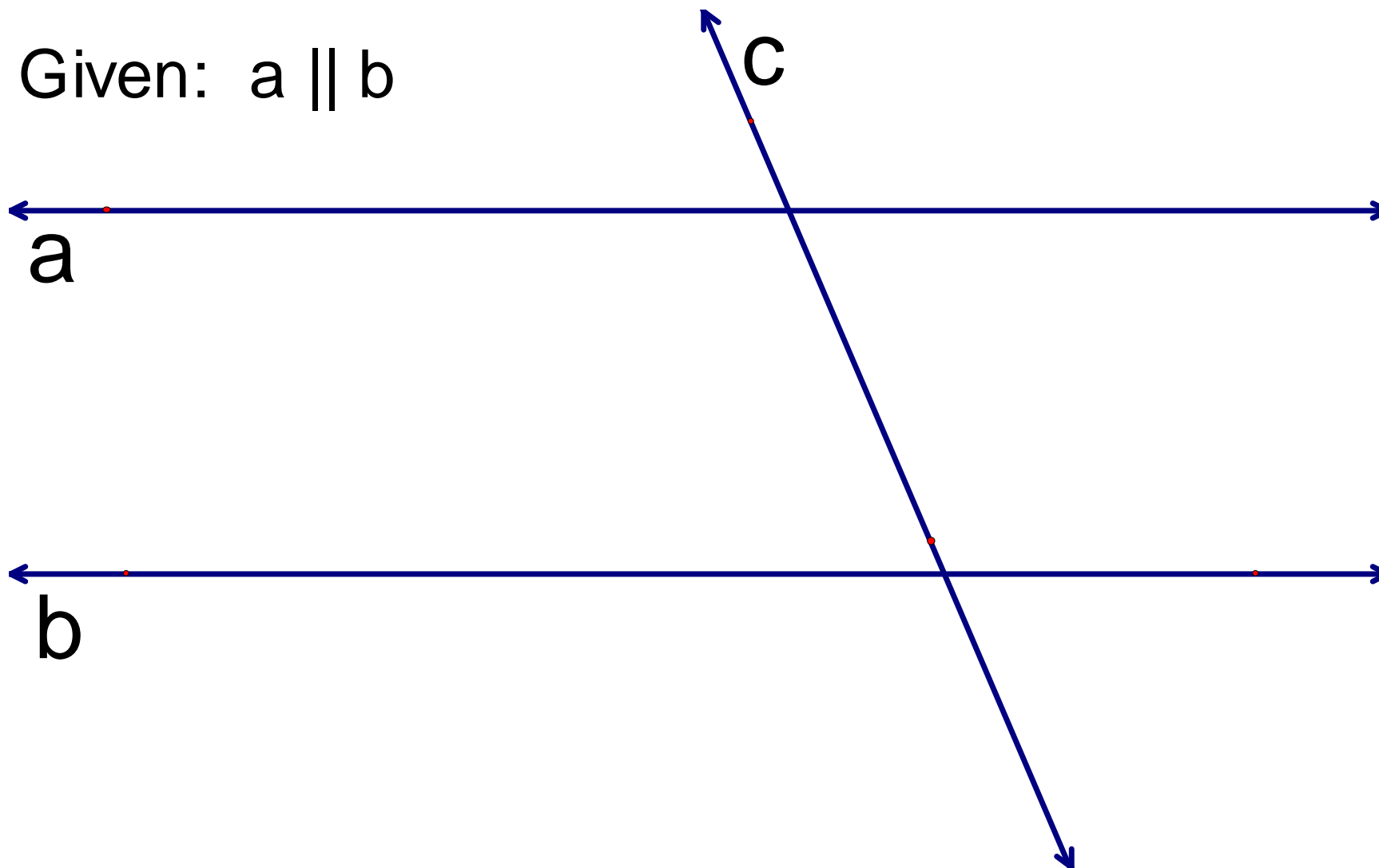
Submarines

Lesson 2/Extension

The photo on the right shows a man looking through a periscope. A periscope is an optical instrument on a submarine made up of a long, narrow tube and mirrors. It allows someone in the submarine to see what's going on above the surface of the water. A diagram of a periscope is shown below. Construct a simplified model of a periscope using Geometer's Sketchpad. The two mirrors at either end are parallel to each other, so that light coming in is reflected at the same angle to the viewer. Your diagram should look similar to the one shown below right.
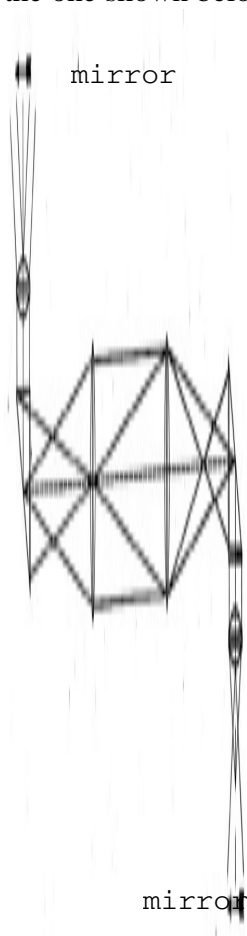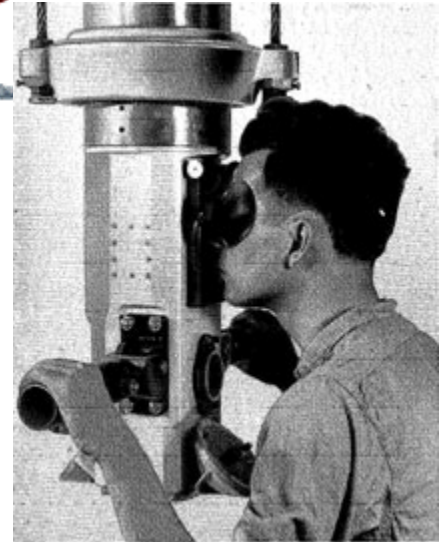
Figure 1 - Periscope   Figure 2 – Simplified Model

Now extend the parallel lines and the transversal and create eight angles. Label pairs of angles using terms learned in Lesson 1.

2

1

4

3

5

6

7

8
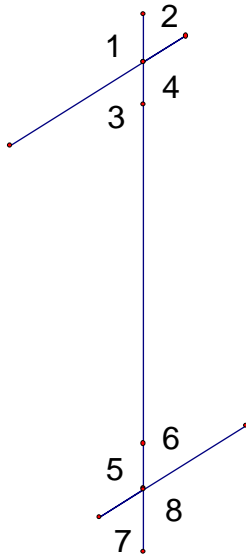
List all angles which are congruent to Angle 1.

_____

List all angles which are congruent to Angle 2.

_____

Which part of the instrument is the "transversal"?

_____

References for Photographs

http://www.maritime.org/fleetsub/pscope/chap1.htm

http:/www.chinfo.navy.mil/navpalib/images/imagesub7.html

http:/www.dutchsubmarines.com/pictures/images/tijgerhaai2/scope_tiggerhaa02_trafalgar.jpg

Photograph taken from a Periscope. Notice the circular part near the upper left.
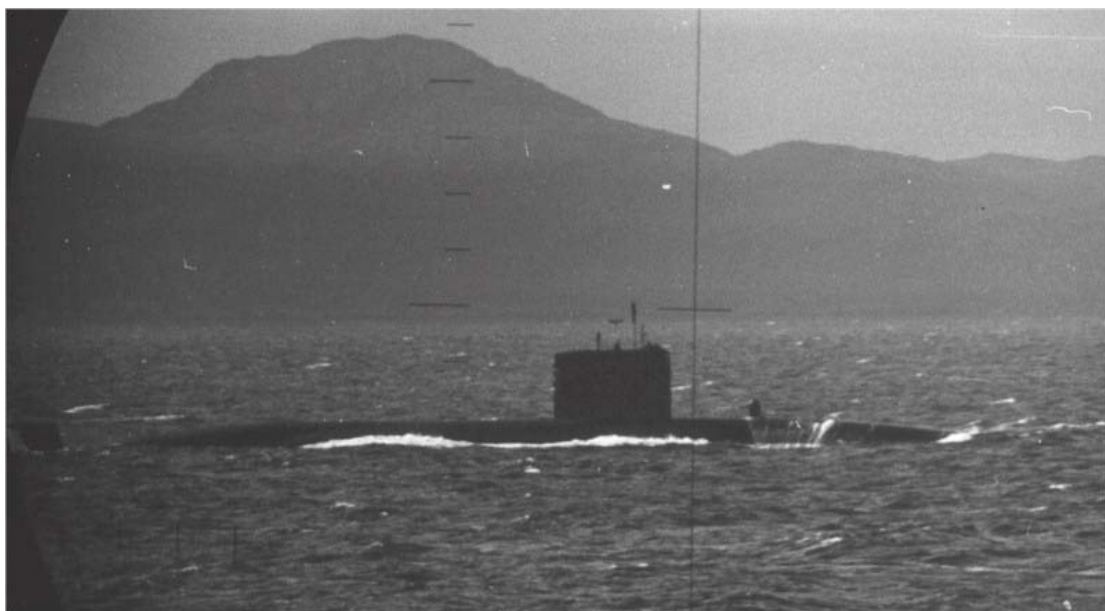
Lesson 3 - Proving Lines Parallel

Pre-assessment / Launch –
   The teacher should display the following diagram so that the entire class can view and
   discuss it together. (The teacher may use the included transparencies or reproduce the
   diagram in Geometer's Sketchpad.) Student worksheets are to be completed using
   Geometer's Sketchpad. The activities can be easily adapted to use compass,
   protractor, paper and pencil.

Given: a || b
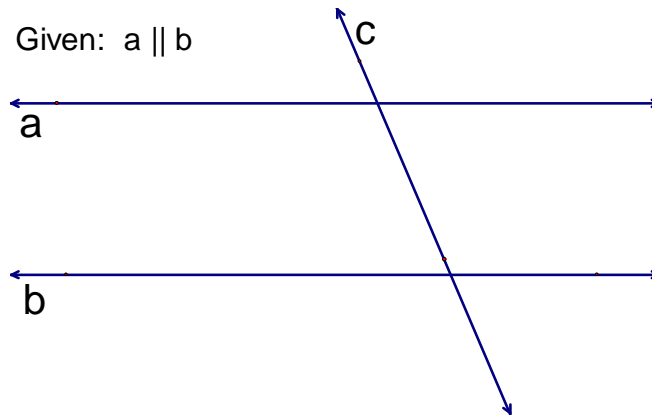
         Review, if necessary, the relationship of the various pairs of angles as covered in
lesson 1.
                  -   Corresponding angles
                  -   Same-Side Interior angles
                  -   Alternate Interior angles

Teacher Facilitation / Student Application
         Student should work on "Worksheet 3.1". Teacher should refer to the solution of
         "Worksheet 3.1 Key" for facilitation information.

Embedded Assessment
         Student should work on "Worksheet 3.2". Teacher should refer to the solution of
         "Worksheet 3.2 Key" for facilitation information.

Extension
         Student should work on "Worksheet 3.3". Teacher should refer to the solution
         titled " Worksheet 3.3 Key" for facilitation information.

Given: a || b
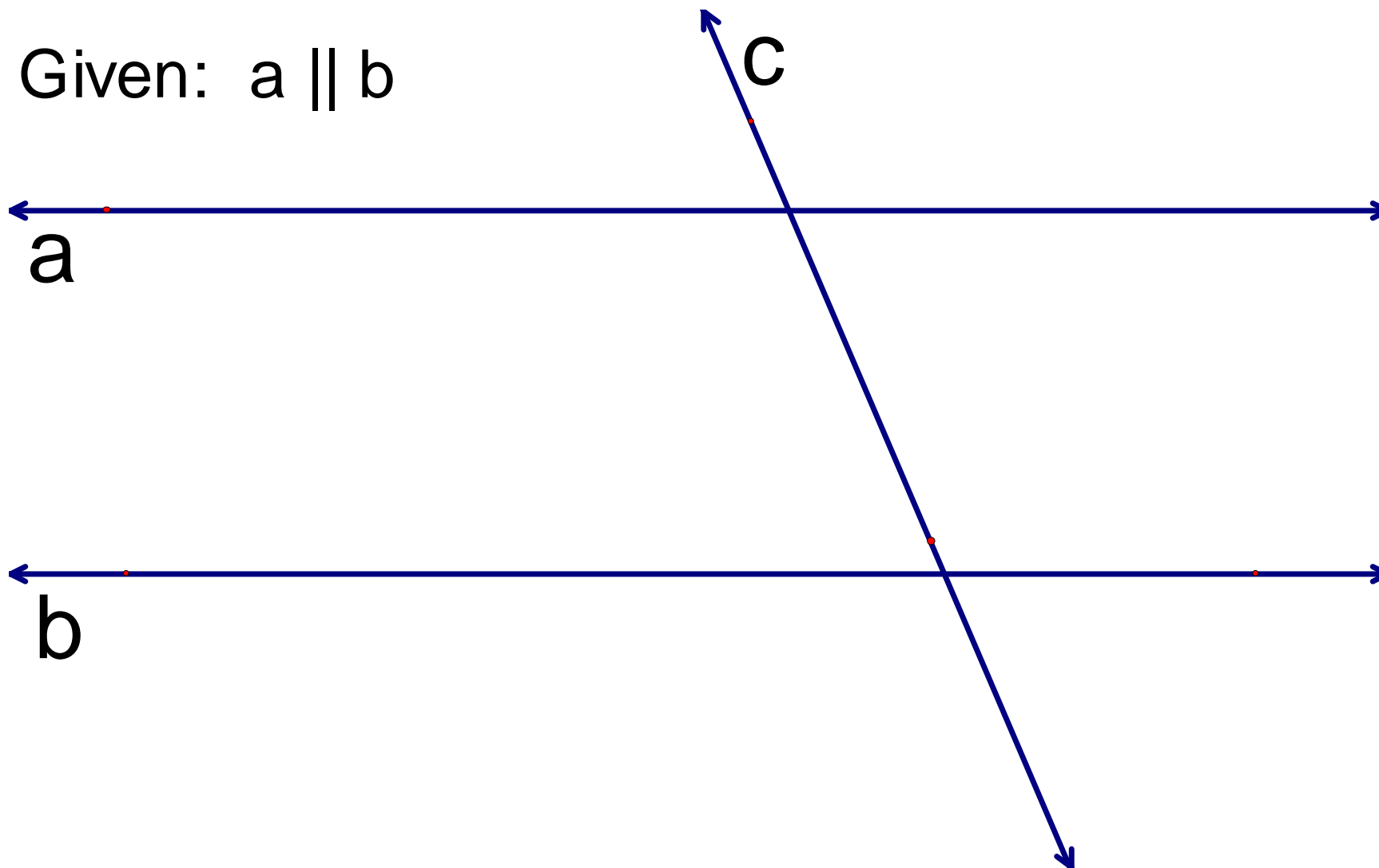
c

a

b

1. Using Geometer's Sketchpad, construct two parallel lines and a transversal.
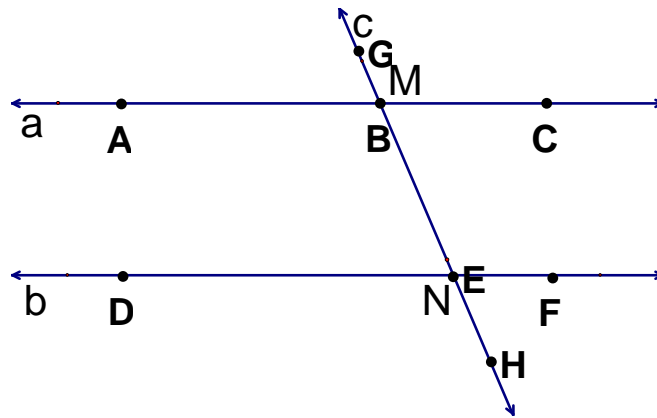   Construct the intersection points as indicated.
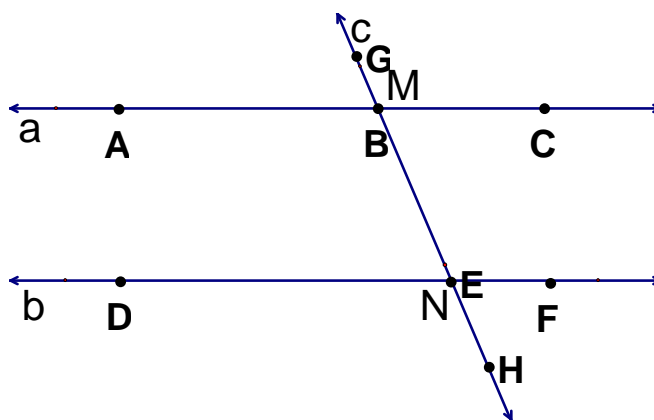
Figure 1

2. Verify that the lines are parallel by checking the measurements of a pair of angles.
   Display the angle measurements. Note: It is assumed that the students need to
   construct points in order to measure angles.

3. Using your diagram, construct angle bisectors d and e.
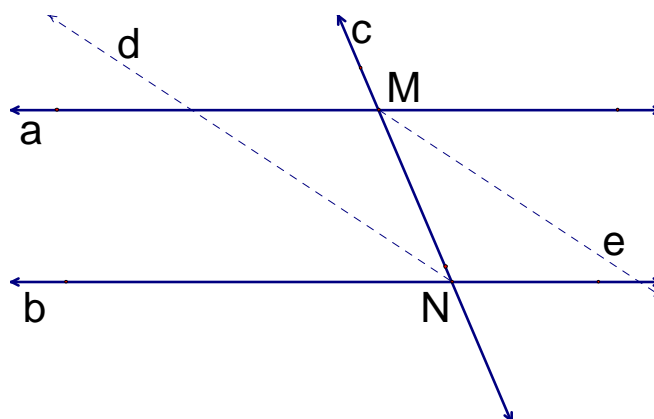
Figure 2

4. Are lines d and e parallel? _____

    Justify your answer.

    _____

    _____

    _____

    Can you think of a way to prove your answer without measuring angles? Explain.

    _____

    _____

    _____

    _____

    _____

    _____

5. Construct line f through point M, perpendicular to line d.
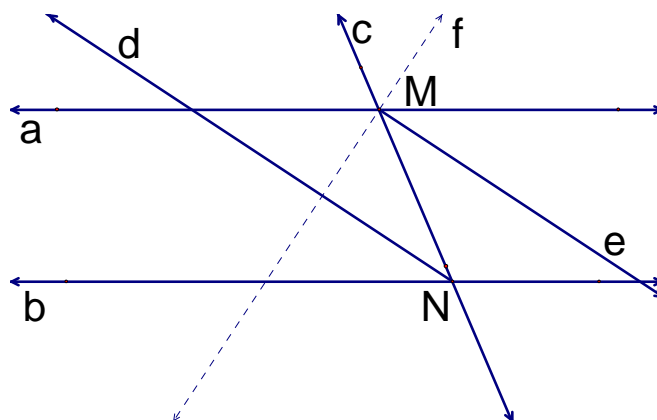
Figure 3

6. Construct angle bisector g.
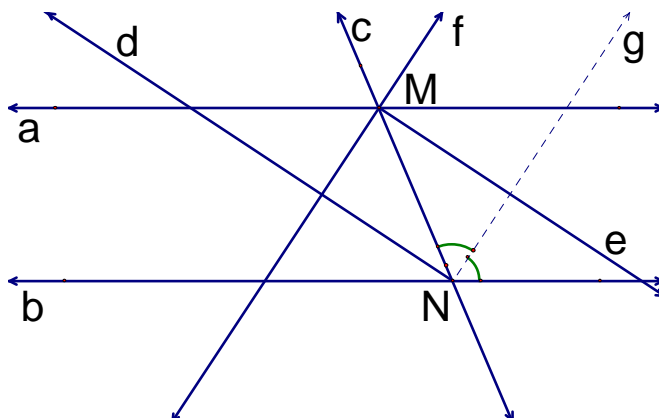
Figure 4

7. Are lines f and g parallel? _____

   Justify your answer.

   _____

   _____

   _____

   Can you think of a way to prove your answer without measuring angles? Explain.

   _____

   _____

   _____

   _____

   _____

   _____

NAME_____**DATE**_____

1. Using Geometer's Sketchpad, construct two parallel lines and a transversal.
   Construct the intersection points as indicated.

Figure 1

2. Verify that the lines are parallel by checking the measurements of a pair of angles.
   Display the angle measurements.

> *Throughout the student activity, the teacher can drag an appropriate point on one of the lines to verify the constructions of the student.*
>
> *Teacher should walk around the room and verify diagrams by checking measurements of pairs of angles*
> *- corresponding angles are congruent*
> *- alternate interior angles are congruent*
> *- same side interior angles are supplementary*

3. Using your diagram, construct angle bisectors d and e.
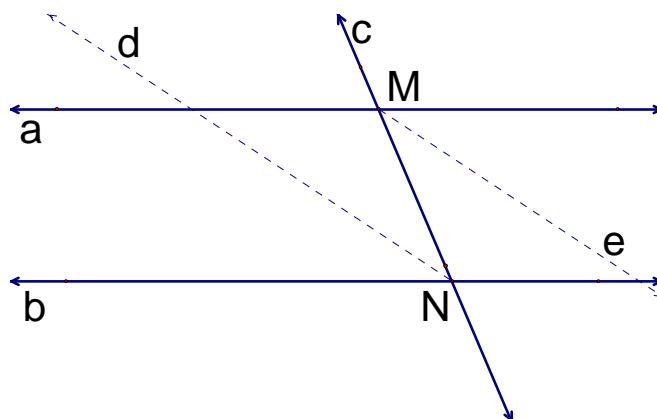
Figure 2

- *Remind the student to select the points in the correct order according to the angle to be measured.(If there is not a point on a particular line, the student will need to construct it.)*
- *After selecting the points, from the Construct menu, select "angle bisector".*

4. Are lines d and e parallel?   <u>yes</u>

   Justify your answer.

- *Measure the angles that were formed after the bisection. The student should notice the following relationships:*

  - corresponding angles are congruent
  - alternate interior angles are congruent
  - same side interior angles are supplementary

Can you think of a way to prove your answer without measuring angles? Explain.

- *Before drawing the angle bisectors, notice that alternate interior angles are congruent.*

- *After bisecting the angles, notice that half of congruent angles are congruent.*

- *These new angles are alternate interior angles of lines d and e. If alternate interior angles formed by 2 lines cut by a transversal are congruent, then the lines d and e are parallel.*

5. Construct line f through point M, perpendicular to line d.
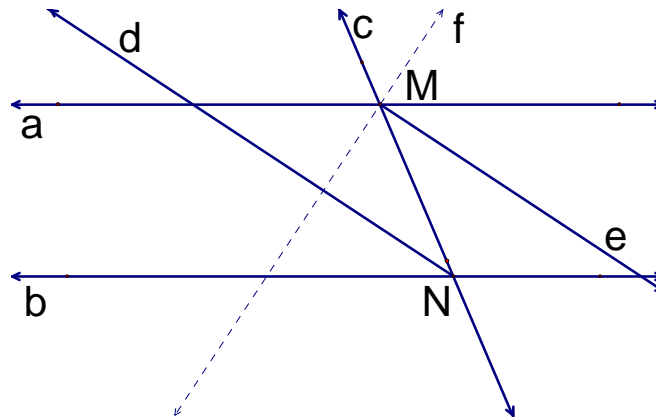
Figure 3

- *Teacher can drag point M to verify the construction of the lines.*
- *Teacher can ask the student to display the measurement of one of the angle created from the perpendicular lines.*

6. Construct angle bisector g.
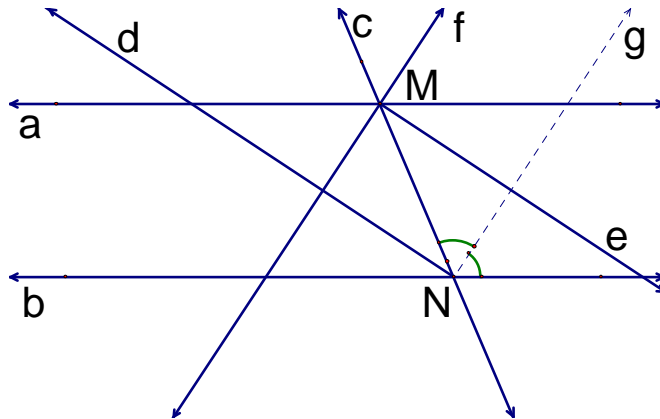
Figure 4

- *Verify that the student constructs the bisector of the correct angle.*
- *Have the student display the measurement of the two angles created by this bisector, and verify their measures are equal.*

7. Are lines f and g parallel? _yes_

   Justify your answer.

- *Measure and verify one of the following:*

  - corresponding angles are congruent

  - alternate interior angles are congruent

  - same side interior angles are supplementary

Can you think of a way to prove your answer without measuring angles? Explain.
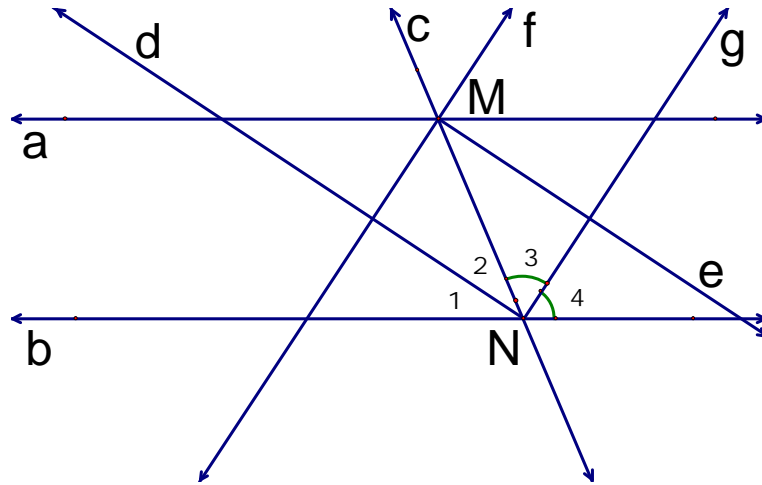
The diagram is redrawn with particular angles numbered. The proof is as follows:

m<1 = m<2 (Angle Bisector Theorem)

m<3 = m<4 (Angle Bisector Theorem)

m<1 + m<4 = m<2 + m<3 (Addition Property of Equality)

m<1 + m<4 + m<2 + m<3 = 180 (Angle Addition Postulate)

m<2 + m<3 = 90 (Subtraction Property of Equality)

g ⊥ d (definition of perpendicular lines)

f ⊥ d (given – constructed in previous diagram)

g || f (If 2 lines are perpendicular to the same line, then the two lines are parallel._)

Construct two parallel lines cut by a transversal
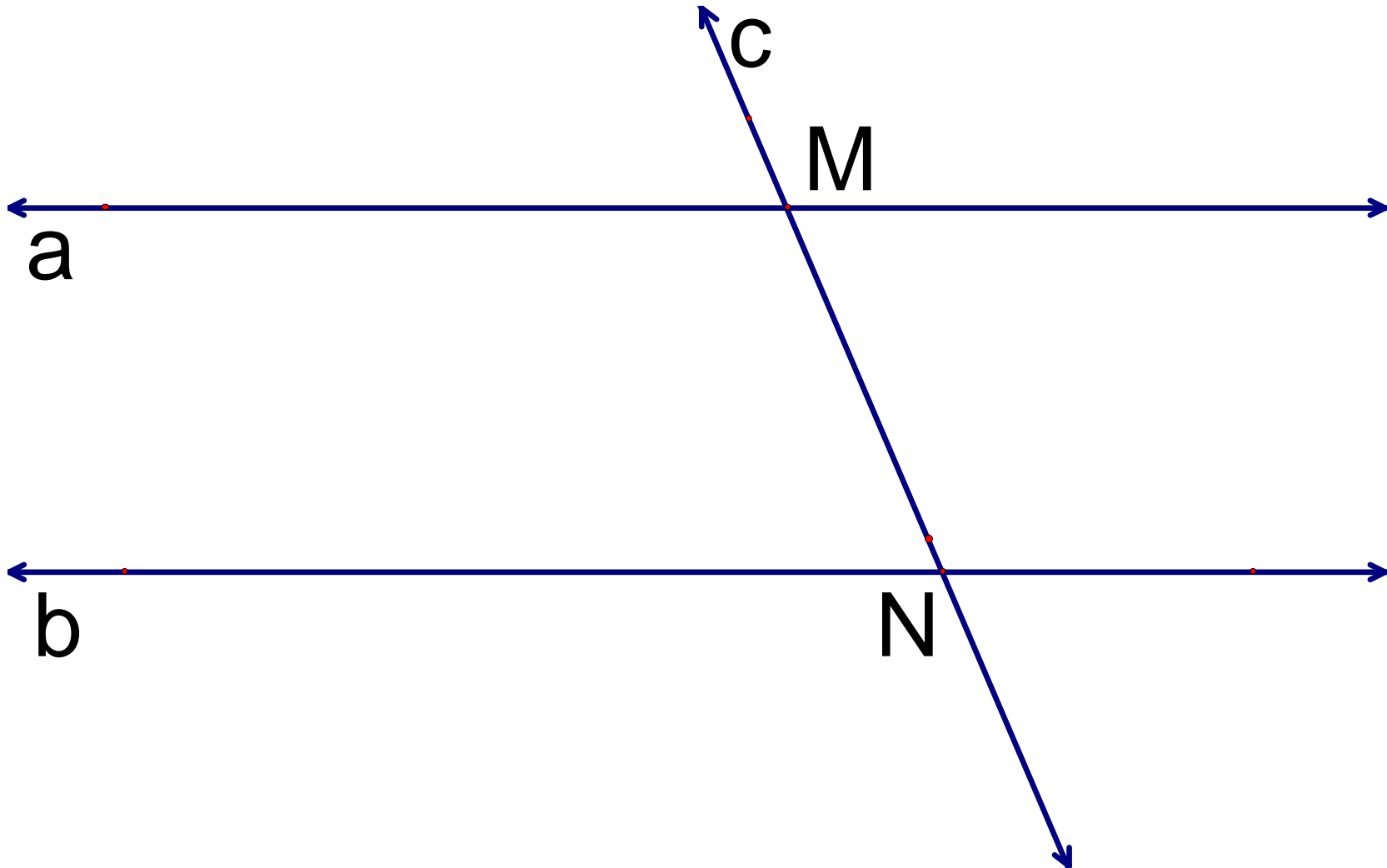
Construct angle bisectors d and e.
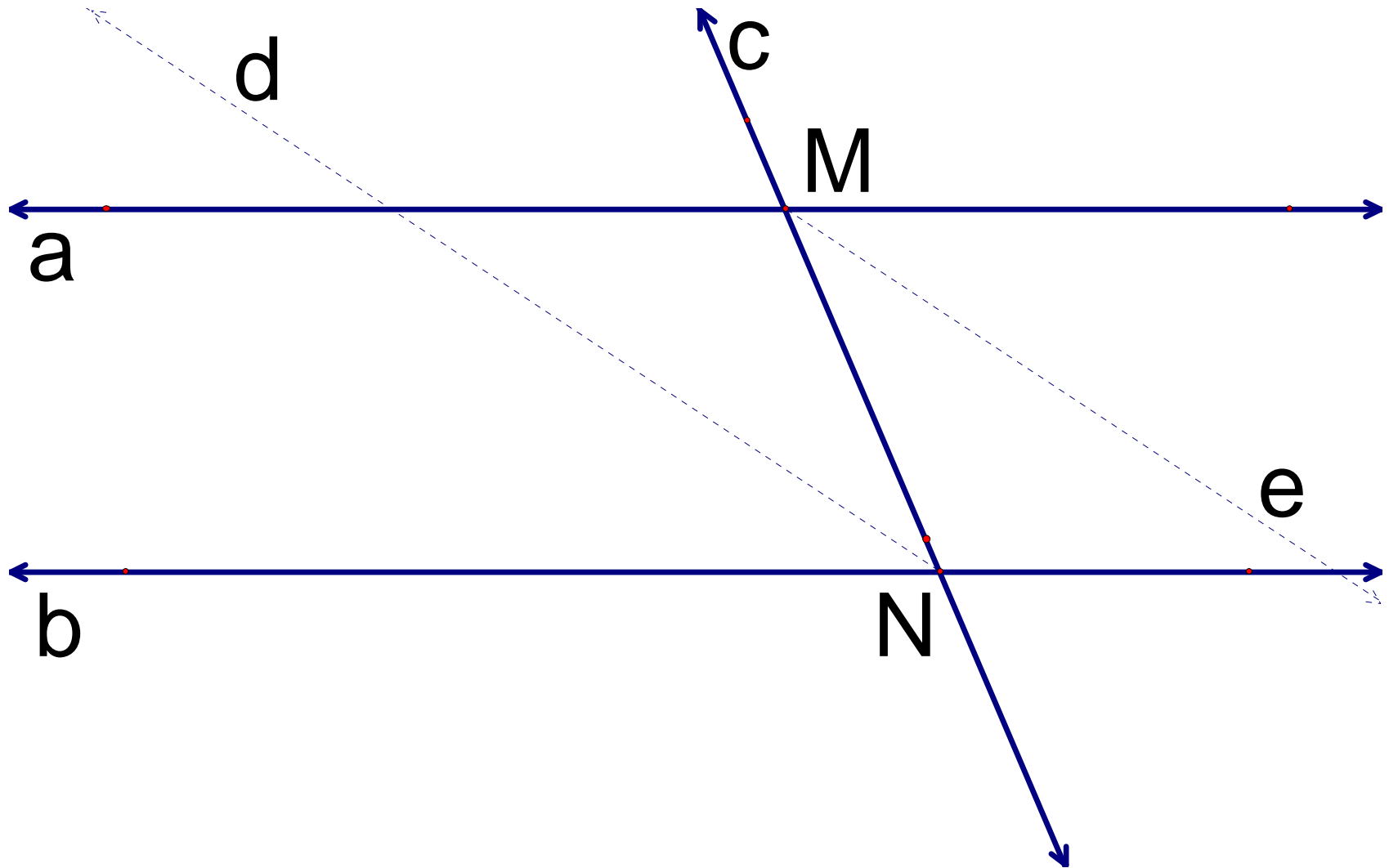
Construct line f through point M, perpendicular to line d.

Construct angle bisector g.

f ∥ g ?

a

b

c

d

e

f

g

M

N
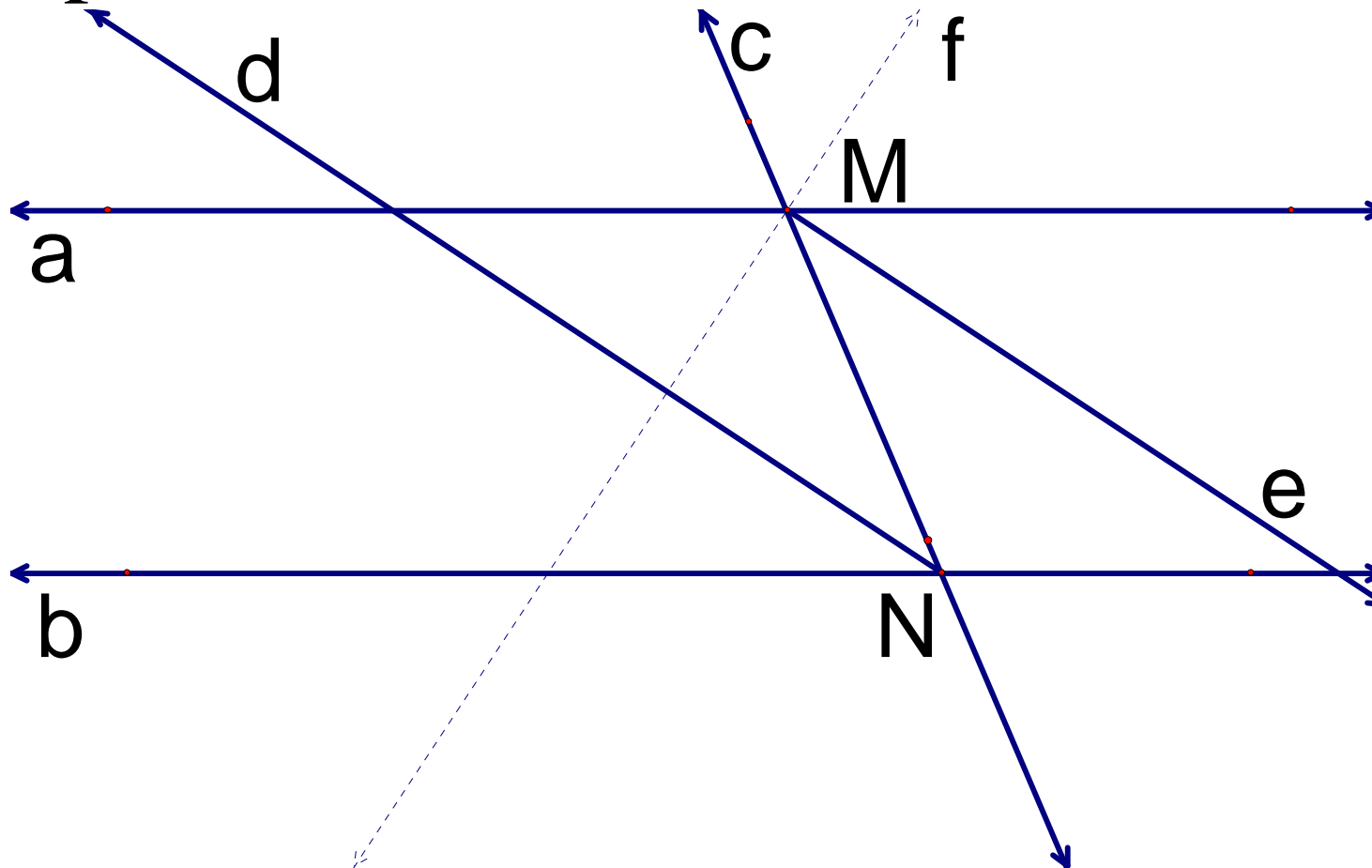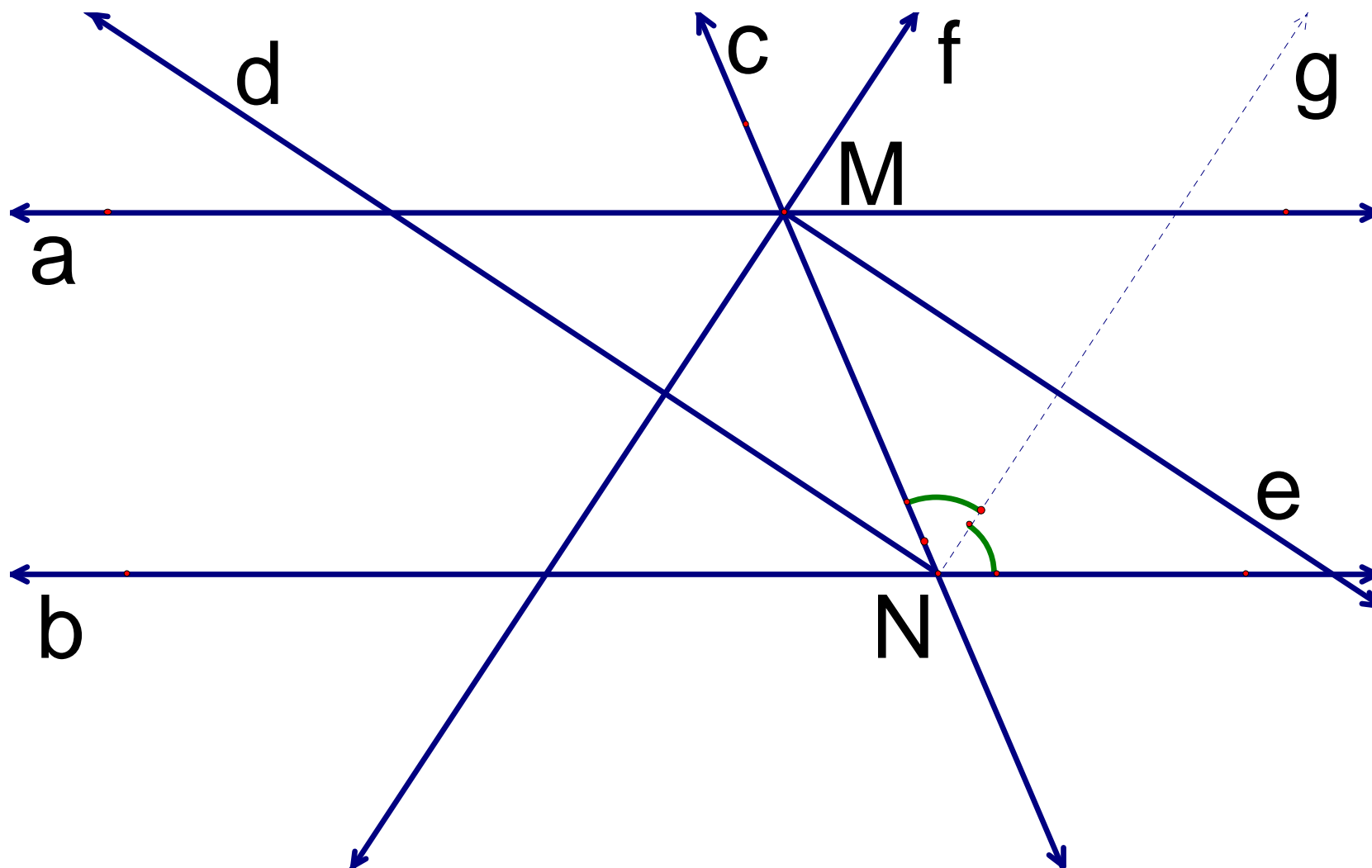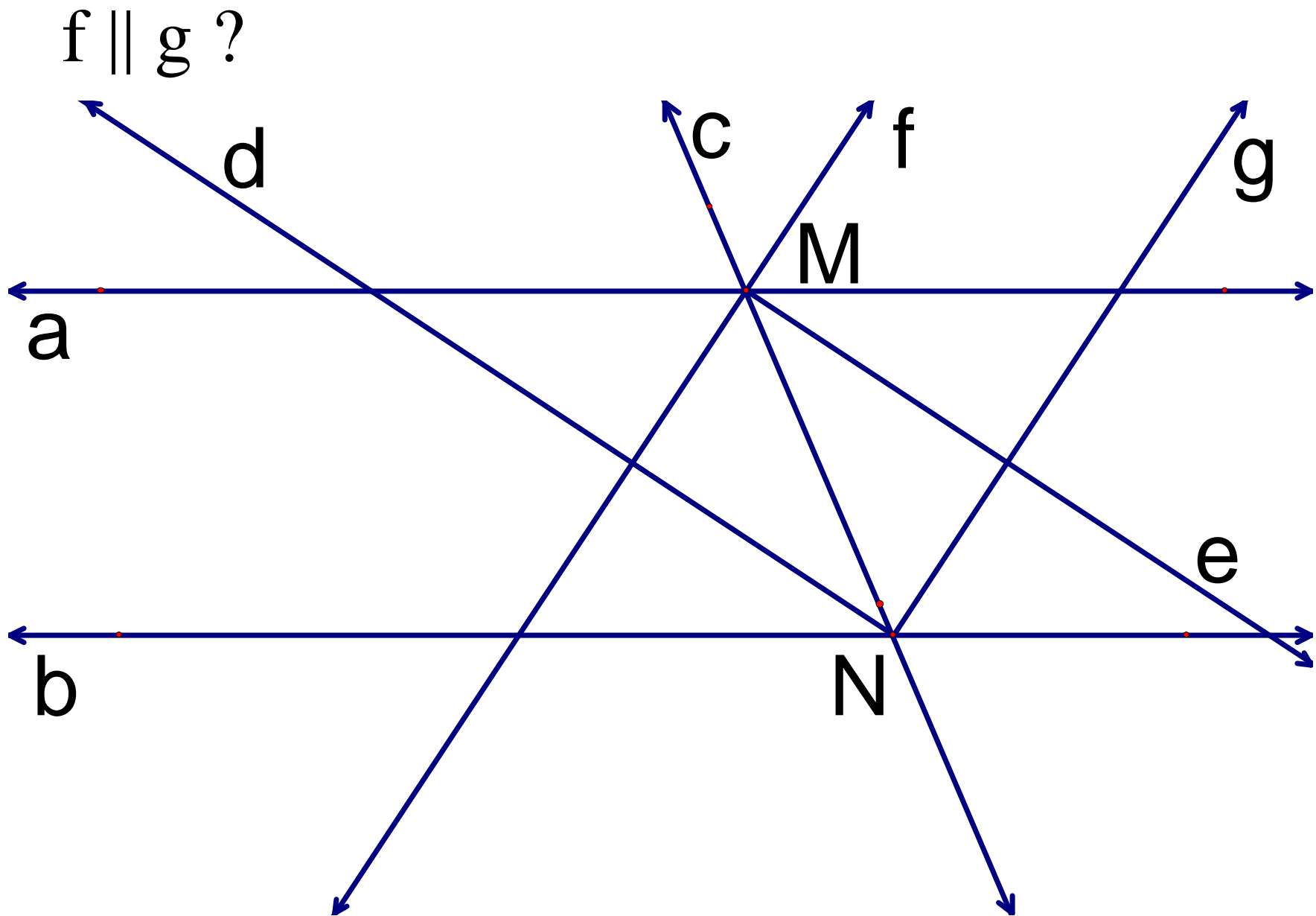
Worksheet 3.2

NAME_____DATE_____

Using the information given in questions 1-10, identify which two lines (if any) can be proven parallel. If none can be proven parallel, write "none".
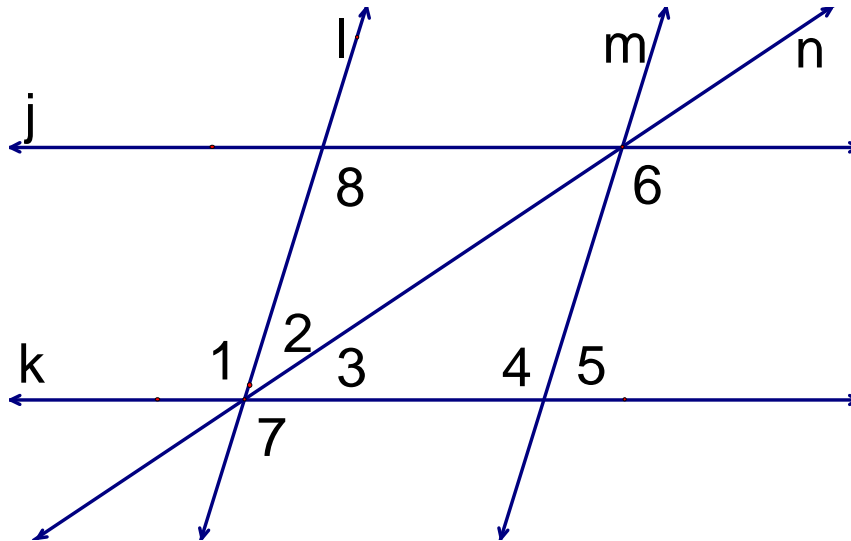
Given Information	Which lines are parallel? If there are no lines parallel for the given information, write "none"
1. $m{<}1 = m{<}4$	_____
2. $m{<}6 = m{<}4$	_____
3. $m{<}2 + m{<}3 = m{<}5$	_____
4. $m{<}2 + m{<}3 + m{<}8 = 180$	_____
5. ${<}6 \cong {<}8$	_____
6. ${<}7 \cong {<}1$	_____
7. $m{<}1 = m{<}8 = 75$	_____
8. ${<}5$ and ${<}6$ are supplementary	_____
9. ${<}4$ and ${<}5$ are supplementary	_____
10. ${<}2$ and ${<}3$ are complementary and $m{<}5 = 90$	_____

Worksheet 3.2 Key

NAME_____DATE_____

Using the information given in questions 1-10, identify which two lines (if any) can be proven parallel. If none can be proven parallel, write "none".

Given Information	Which lines are parallel? If there are no lines parallel for the given information, write "none"
1. $m{<}1 = m{<}4$	l, m
2. $m{<}6 = m{<}4$	j, k
3. $m{<}2 + m{<}3 = m{<}5$	l, m
4. $m{<}2 + m{<}3 + m{<}8 = 180$	j, k
5. ${<}6 \cong {<}8$	l, m
6. ${<}7 \cong {<}1$	none
7. $m{<}1 = m{<}8 = 75$	j, k
8. ${<}5$ and ${<}6$ are supplementary	j, k
9. ${<}4$ and ${<}5$ are supplementary	none
10. ${<}2$ and ${<}3$ are complementary and $m{<}5 = 90$	l, m

Worksheet 3.3

NAME_____DATE_____

Given $\overline{AB} \parallel \overline{DE}$, show that M<ACD = M<BAC + M<CDE. Explain how you
determined your answer.

A

B

C

D

E

_____

_____

_____

_____

_____

_____

_____

_____
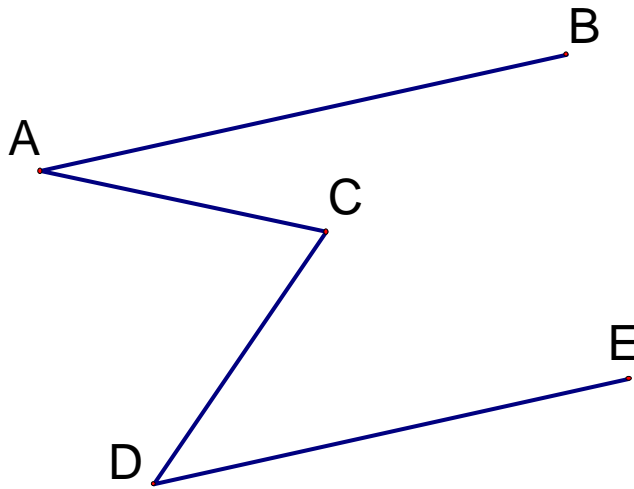
Worksheet 3.3 Key

NAME_____DATE_____

Given $\overline{AB} \parallel \overline{DE}$, show that M<ACD = M<BAC + M<CDE. Explain how you
determined your answer.
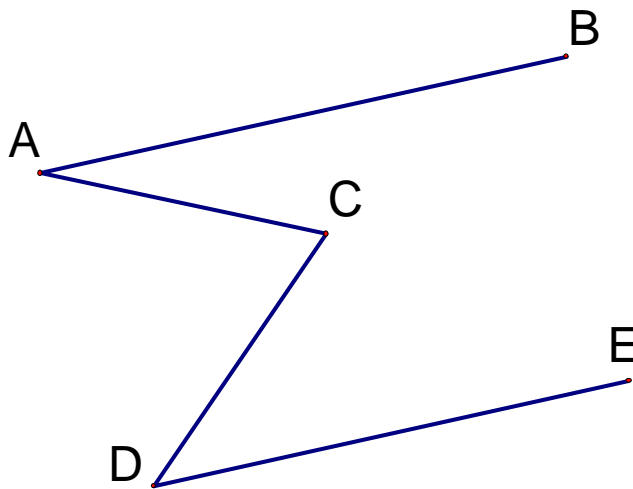
m<ACD = m<BAC + m<CDE

Explanations will vary.

Two possible explanations are

a) extend CD to intersect AB, label

   Intersection E.

   M<ACD = M<BAC + M<CEA

     (exterior angle theorem)

   M<CDE = M<CEA (alt interior angles)

   M<ACD = M<BAC + M<CDE

     (substitution)
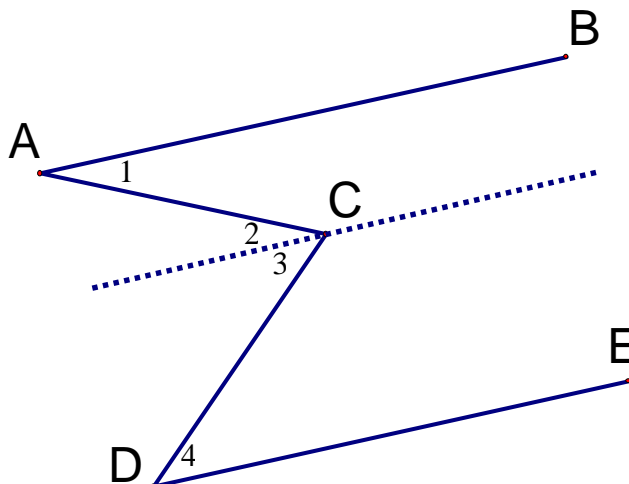
b) construct || line through point C

   <1 = <2 (alt interior angles)

   <3 = <4 (alt interior angles)

  M<ACD = M<2 + M<3

  M<ACD = M<BAC + M<CDE

NAME_____**DATE**_____

Summative Assessment

Summative Assessment. Teachers can select problems from the following to provide a summative assessment of student progress.

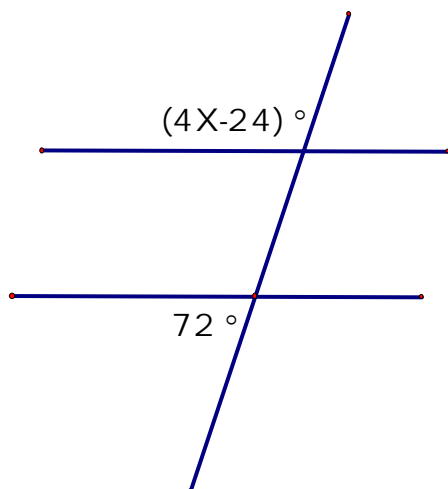1. Complete the statements by filling in the blanks.
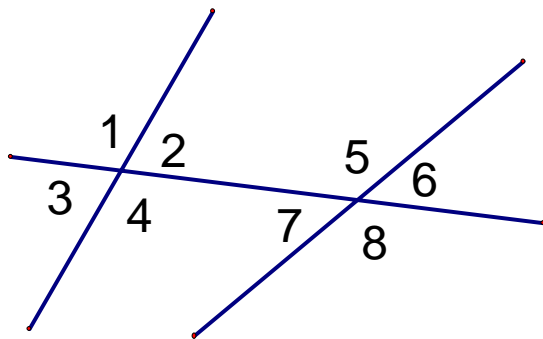
1. <3 and <_____ are corresponding angles.

2. <4 and <_____ are alternate interior angles.

3. <5 and <_____ are same-side interior angles.

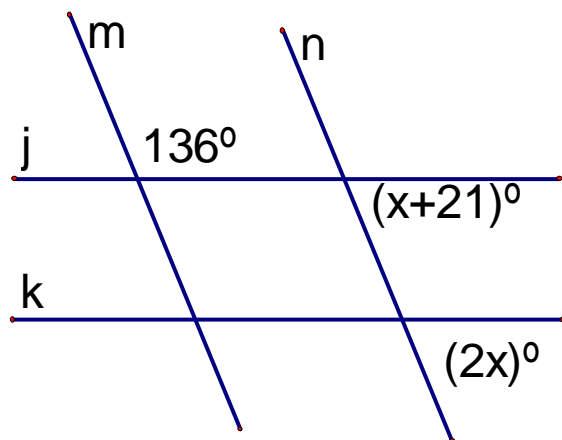2. Given the information in the sketch that follows, find the measure of all angles.
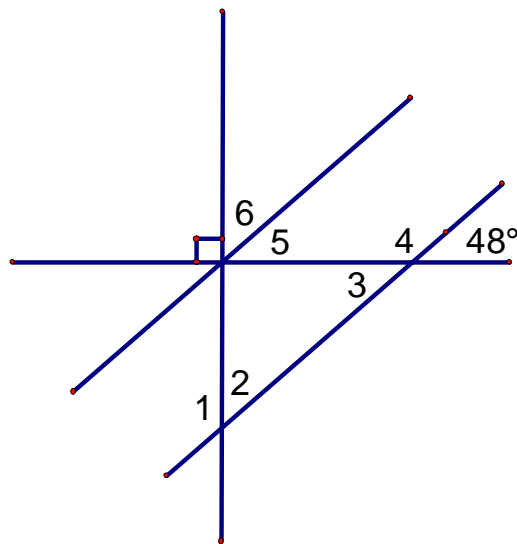
1. m<1 = _____

2. m<2 = _____

3. m<3 = _____

4. m<4 = _____

5. m<5 = _____

6. m<6 = _____

3. Find the value of x.

$(4X-24)°$

$72°$

$x = $ _____

4. Find the value of x.

m   n

j $136°$

$(x+21)°$

k

$(2x)°$

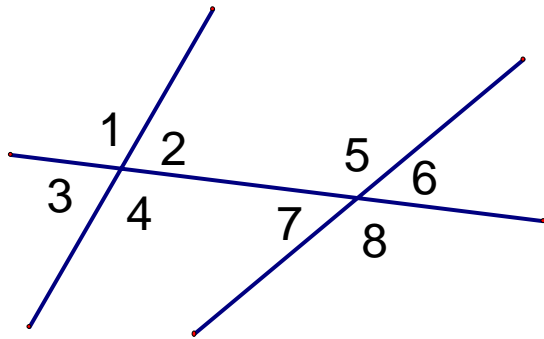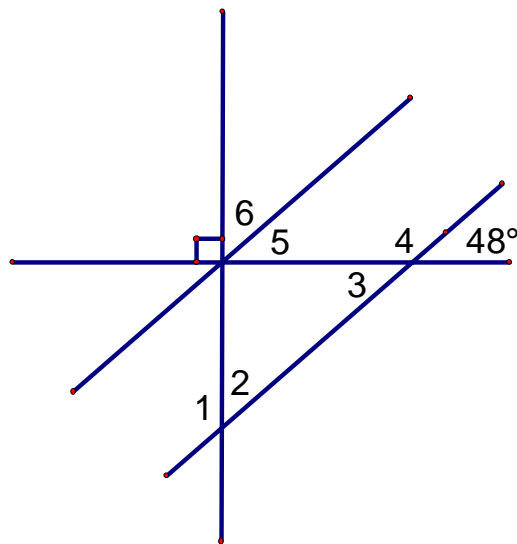If j || k, what is the value of x? Show your work in determining your answer.

If m || n, what is the value of x? Show your work in determining your answer.

NAME_____**DATE**_____

Summative Assessment - Key

Summative Assessment. Teachers can select problems from the following to provide a summative assessment of student progress.

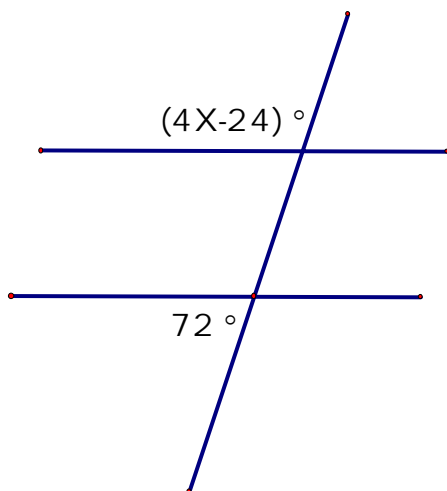1. Complete the statements by filling in the blanks.

1. <3 and <_7___ are corresponding angles.

2. <4 and <_5__ are alternate interior angles.

3. <5 and <_2____ are same-side interior angles.

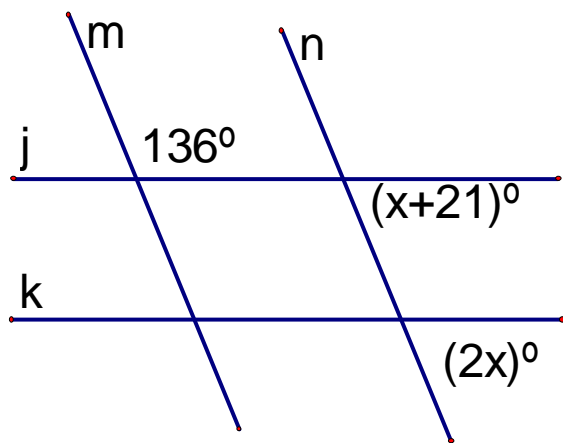2. Given the information in the sketch that follows, find the measure of all angles.

1. m<1 = _138_

2. m<2 = _42_

3. m<3 = _48_

4. m<4 = _132_

5. m<5 = _48_

6. m<6 = _42_

3. Find the value of x.

(4X-24) °

72 °

x = ___24___

4. Find the value of x.

m

n

j   136⁰

k

(x+21)⁰

(2x)⁰

If j || k, what is the value of x? Show your
work in determining your answer.

$x + 21 = 2x$ (corresponding angles)
$x - x + 21 = 2x - x$
$21 = x$

If m || n, what is the value of x? Show your
work in determining your answer.
$180 - 136 = 44$

$x + 21 = 44$
$x + 21 - 21 = 44 - 21$
$x = 23$